HERBICIDES and DEFOLIANTS in War :

The Long-term Effects on Man and Nature

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FOREWORD

The Second Indochina War of 1961—1975 is, among other things, notable for the massive employment of anti-plant chemical warfare agents (herbicides or plant defoliating and killing chemicals). Primarily during the mid to late 1960's the USA sprayed approximately 72 million litres of these herbicides over some 1.7 million hectares of rural South Vietnam that is about one hectare in every ten. At least 12% of the forests of South Vietnam were sprayed one or more times as were 5% or more of the agricultural land.

The three major chemical warfare agents employed in this anti-environmental program (referred to as Operation Ranch Hand by the US Air Force) were :

1. Agent Orange (accounting for 44 million litres or 61% of the total)

2. Agent White (20 million litres, 28%)

3. Agent Blue (8 million litres, 11%)

Agent Orange is a mixture of 2, 4-D and 2, 4, 5-T, and also contained traces of dioxin (TCDD) as an impurity.

Agent White is a mixture of 2, 4-D and picloram.

Agent Blue is dimethylarsenic acid.

Agents Orange and White were the agents of choice for forest destruction, whereas Agent Blue, and to a lesser extent Agent Orange, were used in the crop destruction missions.

It is the 44 million litres of Agent Orange that has caused the greatest level of continuing medical concern because of its dioxin contaminant. Dioxin is an extraordinarily toxic animal poison, lethal in minute doses. Moreover, when administered to experimental animals in sublethal quantities it can result in birth defects, genetic damage and cancers.

The "International Symposium on Herbicides and Defoliants in War: The Long-term Effects on Man and Nature" was convened in Ho Chi Minh City from January 14 to 19, 1983 in order to examine the aftermath of this chemical assault on South Vietnam, now that about a decade has elapsed since the spraying. Thus, more than 70 ecological and medical scientists from some 20 countries, both East and West, came together in order to meet with about an equal number of their Vietnamese counterparts. The international participants included some of the top experts in the world in their respective fields of ecological or medical science.

The three primary aims of the symposium were:

1. To evaluate the existing scientific information on the long-term ecological and physiological consequences of the massive employment of anti-plant chemical warfare agents;

2. To identify and foster needed research in these areas with a view to continued restoration and rehabilitation ; and

3. To promote international scientific cooperation.

It was strictly a working conference open only to qualified scientists.

During the course of the symposium the participating scientists not only met in plenary sessions but — more importantly — in one of the following seven working groups: (1) Plant ecology and forestry ; (2) Animal ecology ; (3) Soil ecology ; (4) Coastal and aquatic ecology ; (5) Cancer and clinical epidemiology ; (6) Reproductive epidemiology and (7) Experimental toxicology and chemistry. The international and Vietnamese scientists within each of these working groups prepared a working group report.

We publish in this booklet the final summary report of the symposium and the seven final summary reports of the various working groups. To these documents we add an article compiled by Dr. Nguyen Khac Vien from papers presented by participating Vietnamese scientists.

Hanoi, February 1983.

VIETNAM COURIER

FINAL SUMMARY REPORT OF THE INTERNATIONAL SYMPOSIUM ON HERBICIDES AND DEFOLIANTS IN WAR: THE LONG-TERM EFFECTS ON MAN AND NATURE

(Ho Chi Minh City, 14 — 19 January 1983)

The "International Symposium on Herbicides and Defoliants in War: The long-term effects on Man and Nature" was held in Ho Chi Minh City from 14 to 19 January 1983.

More than 160 scientists and experts from 21 countries as well as observers of FAO, UNEP and UNESCO attended the symposium. They discussed the long-term effects of herbicides and defoliants used by the US armed forces with the agreement of the Saigon administration on man and nature during the Second Indochina War, 1961 — 1975.

At the plenary sessions and working groups the scientists presented some 72 scientific reports and papers dealing with the following problems:

— The scope and nature of Operation Ranch Hand conducted in Vietnam from 1961 to 1971.

— The long-term effects of military herbicides and defoliants on man (29 reports) and on nature (43 reports).

— The results of experimental studies on herbicides in laboratories or in the field on a small scale.

— The results of studies on the consequences of herbicides from accidents occurring in factories producing them and their effects on groups of workers dealing with chemicals used in agriculture.

Scientists exchanged views, evaluated the results of studies in laboratories and in field experiments. They discussed the research work to be conducted in the near future aimed at eliminating the consequences of the indiscriminate use of herbicides and defoliants on a large scale. They also discussed the possibilities of international cooperation in the field of research.

During the time the symposium was held the scientists visited an exhibition displaying all kinds of chemical weapons used during the war and the effects of herbicides and defoliants on nature and man.

Participants in the symposium also visited the Ma Da forest area, Dong Nai province (in the former Long Khanh province, War Zone D, South Vietnam). Here wartime destruction caused to nature remains very apparent. Ma Da can in effect be considered as a model for experimental field studies as regards the direct and indirect effects of herbicides and defoliants on tropical inland forests, including fire. The visit to the Ma Da forest

gave participants a clear idea of the lengthy duration of effects of herbicidal disturbance on the natural restoration of tropical inland forests.

At the symposium scientists were engaged in active work in a friendly atmosphere. Although most scientists met one another for the first time, their discussions and exchanges of views were conducted in an open, straightforward and frank way and in their private capacities, and this helped ensure good results.

The majority of the participants reached agreements on the following:

1. Operation Ranch Hand was essentially a chemical war conducted with herbicides on a large scale in space and time, the first such massive employment in mankind's history of war. It differed completely from explosion accidents or failures in chemical factories. It was conducted in a tropical country and a geographical area which differs from much smaller-scale experiments in laboratories in any country in the world, or from small experiments in laboratories. The results of these studies and occurences are only of partial usefulness to evaluate what happened to Vietnam and the Vietnamese people during Operation Ranch Hand.

The herbicide employed in Operation Ranch Hand included primarily:

1. 2, 4,-D

2. 2, 4, 5,-T (containing dioxin)

3. Picloram

4. Dimethylarsenic acid.

These 4 chemicals were applied primarily in the following 3 mixtures:

1. Agent Orange (a mixture of 2, 4-D and 2, 4, 5-T)

2. Agent White (a mixture of 2, 4-D and picloram)

3. Agent Blue (dimethylarsenic or cacodylic acid).

According to official U.S. figures, about 44 million litres of Agent Orange were used between 1961 and 1970; about 20 million litres of Agent White were used between 1966 and 1971; and about 8 million litres of Agent Blue were used between 1961 and 1971. There is no source of independent verification.

It is impossible to determine how much dioxin was in the Agent Orange, but a conservative estimate is that the total amount was no less than 170 kg.

2. Over the last twenty-odd years, many experimental studies on herbicides and defoliants have been conducted in research bases in many countries. No full agreement has been reached yet on the results and conclusions regarding the effects of chemicals on expermimental animals. However, through many years of research with admirable patience and increasingly precise methods, the majority of scientists recognize that phenoxy and certain other herbicides and defoliants used at a high dose or at a low dose for a long period of time will affect animals: they may be variously mutagenic, carcinogenic or teratogenic.

3. Studies on workers in factories producing herbicides and defoliants have also been conducted

over the last few years. Those studies confirm the toxicity of herbicides, especially of 2, 4, 5-T (2, 4, 5-trichlorophenoxyacetic acid) and of 2, 3, 7, 8-tetrachloro-dibenzo-para-dioxin (TCDD) or dioxin.

The signs of immediate and long-term poisoning due to chlorophenoxyacetic substances have been described in the medical literature in which manifestations considered as characterising such poisoning are: chloracne, porphyria cutanea tarda, asthenia, etc. In human pathology reactions to the pathogenic agents differ from one individual to another; so do the manifestations of the reactions, which renders evaluation and statistics difficult.

4. The symposium reserved most of its time for the evaluation of the long-term effects of chemical warfare in Vietnam. Scientists attending the symposium highly valued the contribution made by Vietnamese scientists who, despite the limited facilities and other difficulties during and after the war, were able to overcome these problems and made valuable research contributions. The reports and suggestions made by Vietnamese scientists at the symposium provided a crucial basis for discussions in the working groups and at the plenary sessions. Large-scale field studies done by Vietnamese scientists in localities in southern Vietnam as well as northern Vietnam have provided many materials of scientific value not previously demonstrated in other countries.

5. Nature in Vietnam has been substantially damaged. This destruction is due to a complexity of reasons. The delegates agreed that the main and

most important cause of this extensive damage to nature is the use of herbicides and defoliants on a large scale. Immediately after the spraying the toxic substances exerted their direct destructive effects on the vegetation and to some extent on animals living in inland or mangrove forests, and on saline water or fresh water animals. The direct and indirect repercusions of these immediate effects have lasted until today. Time has only slowly helped to eliminate these effects and has not yet allowed the restoration of the areas sprayed with toxic chemicals. The restoration can only be slow and occurs most readily on very small areas. Photographs taken from the air or space have only partially reflected the real state of the restoration of tropical forests sprayed with defoliants.

6. Toxic chemicals sprayed on a large scale, with a high concentration and in a large amount, have changed the composition of some soils, destroyed useful microorganisms, and in some instances caused the soil to lose fertility and to deteriorate in other ways. Many areas which were covered with trees and other woody plants throughout the year have become savannas of low productivity with only wild grasses or a number of secondary successional plant species of little economic value, and full of rodents, which are disease-carriers. Evidence from aerial photography and elsewhere indicates that some of these savannas are continuing to expand in size. Some areas of precious tropical woods are facing the danger of extermination, as are some precious terrestrial or aquatic animals and algae, etc. Transforming these savannas and build-

ing them into economic zones, areas for agricultural cultivation and reforestation, are difficult problems, the solution of which is far beyond the present abilities of the Vietnamese people. Moreover, the various impacts on nature undermine the whole human life support system.

7. Toxic chemicals sprayed on the land were washed away to lowland areas, far from the sprayed areas and decomposed in time. The most dangerous among them was Agent Orange, which was widely used from 1961 to 1970. Agent Orange contains an impurity, 2, 3, 7, 8-tetrachloro-dibenzo-para-dioxin (TCDD) generally known as dioxin, a very toxic and resistant substance which exists for a long time in nature. What was the amount of toxic chemicals sprayed? According to published data, more than 90,000 tons of herbicides were sprayed, including more than 57,000 tons of Agent Orange, containing the toxic substance dioxin. However, the most important thing one should know is whether dioxin still exists in nature in Vietnam. In 1981 analyses were made of 7 soil samples taken in a rural area of Ho Chi Minh City, at different depth levels. On a sample taken at a depth of 1 metre there was a trace of dioxin, with a concentration below 5 p.p.t. of soil. On a wet sample on the soil surface the concentration was 14 p.p.t. of soil.

8. There are as yet not many scientific studies identifying the biological cycle of dioxin from the soil into plant species, into food, into animals and people.

Dioxin and decomposition products of herbicides and defoliants have probably been carried to lowland areas in Vietnam and neighbouring countries, and into the seas around Vietnam. Where will these substances end up? How will they be decomposed? What danger will they cause? When will the dioxin decompose? These points cannot yet be established. The opinions put forward at the symposium were only estimates which must be verified over a long period of time.

9. The evaluation of the long-term effects of herbicides and defoliants is a most difficult and complex task. It is therefore difficult to reach full agreement, since the conditions in which scientists work differ from one country to another. However, most of the conclusions drawn by Vietnamese scientists in their reports have corroborated the results of experiments conducted by the majority of scientists in the world and Vietnam. Reports by Vietnamese scientists have suggested that herbicides and defoliants affected chromosomes and caused congenital abnormalities, molar pregnancies and chorio-epithelioma. Vietnam war veterans exposed to toxic chemicals for a long time during the war years may pass on those abnormalities to their offspring. The rate of monsters in families of Vietnam war veterans seems to be higher than in ordinary families. Research studies also give some data as to how toxic chemicals affect people's health and how they cause cancer. Herbicides penetrating into human bodies may cause long-term effects even though the victims have already left the conta-

minated areas. Of course, such effects would be clearer for those who remain in the affected areas.

Any of the preliminary conclusions of Vietnamese scientists are new points, which were observed in the realities of Vietnamese society, and have never been dealt with or else have been only inadequately dealt with in foreign research works.

10. During the symposium scientists agreed that:

a) Further studies should be continued for many years on the long-term effects of herbicides and defoliants used in the war on man and nature in Vietnam.

b) International cooperation between Vietnamese scientists and their foreign colleagues is necessary to promote study and to determine the effects of herbicides and defoliants, and find measures to cope with them, in the interest of the Vietnamese people and other peoples. Thus, this international symposium in Ho Chi Minh City had a humanitarian character, which is serving the interest of the people.

c) Measures to cope with the effects of herbicides and defoliants are complicated and difficult. They involve many fields of science, technology, culture, economy and management and call for appropriate governmental policies. They require a high level of science and technology divorced from politics, the cooperation and commitment of the whole population, and significant investments of money and material. Unrestricted assistance from the international community in all fields related to this endeavor is an urgent necessity.

Finally, a brief separate document provides background information on the subject of the symposium and the following 7 additional documents, provide official summaries of the symposium working groups:

1. Plant Ecology and Forestry;
2. Animal Ecology;
3. Soil Ecology;
4. Coastal and Aquatic Ecology;
5. Cancer and Clinical Epidemiology;
6. Reproductive Epidemiology and
7. Experimental Toxicology and Chemistry.

FINAL SUMMARY REPORT OF WORKING GROUP E 1 ON PLANT ECOLOGY AND FORESTRY

The massive use of chemical defoliants and herbicides in the war against Vietnam is an event without precedent in history. It has produced many effects on the agriculture and ecosystems of Vietnam, only a small part of which are currently understood. We see the need for a large-scale coordinated program to accomplish the following objectives:

1. to establish an accurate inventory of the extent and severity of the damage and changes caused by the defoliation.

2. to estimate the extent of spontaneous regeneration in the forests and other ecosystems. For such work, existence of reliable descriptions of forests of this region provides a necessary base of data.

3. to develop policies of land management, regeneration, and agriculture that will encourage such regeneration, minimize the damage and restore the land and forests to maximum productivity and stability, and

4. to devise systems of international aid and cooperation to implement those beneficial policies which are beyond the financial and technological means of the Vietnamese nation.

Over the decade starting in 1962 at least 14 per cent of South Vietnam's forests were sprayed at least once, and many were sprayed repeatedly. Vietnamese estimates quoted by Hoang Dinh Cau in his plenary lecture set this figure at 44 per cent. The extent of permanent damage is correlated with the total defoliant dose, as judged by matching aerial photographs with military spray records. The degree of initial damage and the rate of recovery from such damage depends on many factors, including the species involved, the dosage, the total area sprayed, the terrain and the weather patterns. Similarly spontaneous regeneration varies widely in the affected areas, and depends mainly on the species, the area affected and the weather. The existence of prolonged dry season in Vietnam certainly impedes regeneration and in some areas natural regeneration has not occurred, making plantations essential. In one studied region, the Dong

Nai forest, regeneration has proceeded very slowly over the last decade, as judged from satellite pictures and on the ground studies.

Frequently, the nearby availability of seeds is the critical factor determining regeneration. The regenerated forest may differ significantly from the original in terms of economically important species. Inventories must be made of these changes.

Once an area has been defoliated, it may be prevented from recovery by human intervention. We note, for example, repeated burning of the grass and small woody cover of defoliated areas such as in the Ma Da forest and the conversion of some such areas to agriculture. Such conversions, once effected, are difficult to reverse and such land might best be left to agriculture.

Once policies have been developed to foster recovery, laws and social practices should be developed to minimize the deleterious effects of those practices that prevent recovery.

The ecological damage produced by herbicidal spray may also become spontaneously worse with time. For example, areas denuded of vegetation may suffer erosion or other deleterious transformation, or they may become invaded by noxious plants such as *Imperata* which impede restoration of the original flora. The extent of such transformation, representing possible permanent loss of forestlands, should be accurately estimated.

With regard to agriculture, some 1.3 million hectares of cultivable area seem to have been lost by the spray operation, partly because of the high concentrations of herbicides used in the spray. The

problems underlying agricultural restoration require separate and intensive study, to determine for example possible danger from toxic residues, effects on soil microflora, and best crops to use in the new agricultural effort in these areas. Making recommendations for vegetational restoration in Vietnam is difficult, because the complexity of the landscape and the variation of local conditions make generalizations impractical and even counterproductive. Each separate area must be given independent analysis. While ingenious and provocative models have been proposed to estimate productivity and performance in a forest ecosystem, it is premature to expect these models to be usefully employed in the field in Vietnam. We are impressed by the high quality and prodigious quantity of work accomplished by our Vietnamese collegues under difficult conditions and with very little support. This encourages us to urge that their research be supported in concrete terms.

Such information as we now have, admittedly fragmentary, permits the conclusion that the combined ecological, economic and social consequences of the defoliation operation are vast, and will take several generations to reverse, and deem it appropriate that international agencies adopt steps to condemn such warfare against the environment and to ban such practices from any future military operations.

Pilot schemes:

We believe that a useful approach to restoring the forest resources would be by means of a pilot

scheme for a small selected area. This could be started immediately and would provide valuable experience while a large long-term scheme was being organized. The forest at Ma Da which we visited in January might be suitable for such an experiment within this forest if protected from fire. It would be possible to find (1) areas of undamaged forest which could serve as seed sources and a base of reference (2) areas of herbicide-damaged forest needing to be restored to full productivity by encouraging natural regeneration or by conversion to plantation of pines or oilier fast-growing trees and (3) areas of scrub and grassland which might be re-afforested. The cost of such a pilot scheme would not be large and could perhaps be met by grants from UNEP, FAO and UNESCO.

FINAL SUMMARY REPORT OF WORKING GROUP E 2 ON TERRESTRIAL ANIMAL ECOLOGY

Chemical defoliants were sprayed in high concentrations and over large areas of forest in South Vietnam from 1961 to 1971, damaging the forest environment and causing the death of countless animals. The working group reviewed two papers reporting the results of two years of study of the effects of massive herbicidě-spraying in A Luoi valley, Binh Tri Thien (formerly Thua Thien and

Quang Tri) province. This 10,000-ha valley was 80% tropical forest supporting a rich fauna, but was degraded to grassland. A research team led by Professor Vo Quy of Hanoi University interviewed a cross-section of the inhabitants of ten villages in the valley who witnessed the immediate results of chemical spraying. These people consistently reported that spraying was followed within a few days by the death of large numbers of both wild and domestic birds and mammals. There have been no studies investigating the contribution to this mortality from direct toxic effects of chemicals versus indirect effects such as starvation or disease that would follow the destruction of the forest environment of animals.

An important comparison between A Luoi valley and two control forest areas of numbers of bird species, by professor Vo Quy, and number of mammal species, by Dr Dang Huy Huynh, was presented and discussed. Only 24 species of birds and five species of mammals were found in A Luoi valley, while 145 and 170 bird species and 30 and 55 mammal species were censused in the control forests.

Two other studies were reported. Dr. L. N. Medvedev stated that termite abundances were lower in a sprayed forest site compared to an unsprayed forest site of similar forest structure. Dr. Tran The Thong reported higher incidences of reproductive problems and birth abnormalities among domestic pigs in a village subjected to chemical spraying compared to an unsprayed village.

Visits to defoliated forests and examination of aerial photographs of sprayed and unsprayed

forests have shown that tropical forest has been transformed by chemical warfare to two types of degraded vegetation. First, forest repeatedly or intensely defoliated over large areas was often subsequently burned, leading to the establishment of grassland. Examples are A Luoi valley and large areas within and to the north of Ma Da forest reserve, Dong Nai province. Second, over large areas of forest less frequently sprayed, plants of the upper layers of the forest were killed, resulting in a forest of low stature relatively poor in animal species. Thus in defoliated areas, tropical forest supporting a rich fauna of invertebrates and vertebrates has been destroyed, together with the animals dependent on the microclimatic conditions, food resources, and physical structure of the forest. Populations of animals requiring forest of well-developed structure and high plant species diversity have been reduced and subdivided into isolated areas. These species are now more susceptible to local extinction as a result of the reduction and division of their forest habitats. This phenomenon was specifically investigated during surveys of endangered species, for example, *Rhinoceros sondaicus, Bos sauveli, Pygathrix namaeus* and *Lophura edwordeii,* and of economically important vertebrates in seven forest areas of South Vietnam by Vo Quy and colleagues.

We suggest the following objectives for further research on the ecological impact of chemical warfare on forest animals. First, thorough ecological

and zoological studies are necessary, especially to quantitatively document differences in animal species richness and abundances in sprayed and unsprayed areas of different types of forest. Second, field ecological studies should be combined with laboratory investigations of particular animal taxa to discover species useful as bioindicators of herbicides and/or ecosystems, and to investigate if long-term reproductive problems have resulted from genetic damage to wild and domestic animals surviving chemical poisoning. Third, the distribution of any residual chemicals in the ecosystem should be assessed. Fourth, long-term research plots in forest recovering from chemical spraying should be established to monitor changes in their animal communities. Fifth, more surveys should be conducted to identify and categorize the remaining forests of southern Vietnam and their animal components.

We stress that recommendations from animal ecologists for forest rehabilitation must be integrated with economic studies of how best to utilize these altered lands for the economic and social needs of the people. We have two immediate recommendations to offer. First, we suggest establishing a system of rational biological reserves to protect and manage what remains of the rich diversity of animal life in the forests of southern Vietnam. Second, we are especially concerned about further reductions in forest cover caused by the spread of grasslands. This process was set in motion by chemical warfare. We suggest that efforts be devoted to reafforesting grassland to rejoin small

patches of forest that are now isolated from one another and form barriers to animal dispersal.

Finally, we suggest that biological institutions within Vietnam seek expert assistance and funds from international agencies such as the Food and Agricultural Organization (FAO), the United Nations Development Program (UNDP), the International Union for the Conservation of Nature (IUCN), United Nations Environmental Program (UNEP), UNESCO [especially its Man and the Biosphere (MAB) program] and the World Wildlife Fund (WWF).

Our working group wishes to emphasize that the complexity of, and interrelationships among these ecological problems require cooperation among botanists, zoologists, soil scientists and aquatic biologists to aid in the rehabilitation of the fauna of forests devastated by chemical warfare.

FINAL SUMMARY REPORT OF WORKING GROUP E3 ON SOIL ECOLOGY

The use of herbicides in the Vietnam war has caused heavy damage and long-term consequences on soil ecosystems and this may affect agricultural and forest production and ultimately man's health. This response of outrage to large-scale wartime

use of herbicides for crop destruction and forest defoliation should not deny the benefits of their use to farmers and workers in the forest during times of peace.

The soil working group was concerned with the effects of the wartime use of herbicides on the chemical, physical, and biological properties of soil.

The effects of herbicides on soil may be indirect or direct. Their indirect effect occurs through changing the vegetation and its influence upon soil properties. Their direct effect occurs when they enter the soil, becoming part of soil organic matter degradation processes or affecting the microbiology of soil. The magnitude of changes induced upon soil properties will vary depending upon other variables which influence the soil ecosystem, for example, the geologic conditions, the topography, and the degree of development of the soil.

Our group heard and discussed papers which dealt with three main soil topics: 1) The changes in soil properties that have occurred since herbicides were applied during the Vietnam war. 2) The effect of the herbicides on the ecosystem of soil micro-organisms. 3) The fate of herbicides entering the soil in the processes of degradation and their resulting products.

The major points made in these reports are:

1. A large proportion of the elements of site fertility are contained in the trees relative to the soil in undisturbed tropical forests. Herbicides bring about a sudden return to the soil of the foliage of vegetation with its elemental content. Rapid decay of this detritus brings a flush of organic matter, nitrogen

compounds and associated mineral elements to the soil. This changes soil properties with the increase in these materials. This may be temporary or long lasting depending upon many factors such as rate of recovery of original vegetation, amount of conversion to other types of vegetation, or land uses and the topography, and degree of erosion.

2. Loss of soil fertility elements may occur depending upon the intensity and duration of vegetation change induced by herbicides. Repeated application resulted in greater opening of forest and conversion to other types of land use. The fertility content of the site in soil and vegetation became less with the sequence from forest to grassland or bamboo. Soil fertility elements most susceptible to loss are potassium and nitrogen, with a drop in available phosphorus due to incorporation in insoluble forms.

3. In a study made in the A Luoi valley, Vo Quy reported changes in soils collected 12 years after herbicide use had converted forest to *Imperata* grassland. Periodically, man-caused fires occur and maintain this grassland. Where topography is steep the changes in soil properties were lower organic matter content, lower nitrogen content, less available phosphorus and lower calcium, magnesium and iron on the soil cation exchange complex. The soil increased in acidity and aluminum content. Where topography was flat as in the valley bottoms with alluvial soils, there were increases in the soil organic matter and nitrogen content.

A study of mangrove forest soils at Ca Mau showed soils in areas cleared of mangroves increased

carbon and nitrogen contents, lower soil pH, available phosphorus was less, and soil potassium was lowered when compared with uncleared forest. Where cleared soils were used for agriculture there was a drop in nitrogen contents but organic matter remained high. Deterioration due to acid sulphated soil formation has occurred in some of these mangrove areas such as U Minh and Ca Mau.

4. Herbicides and pesticides directly entering the soils and transmitted through the plant to root exudates may affect the species composition of soil microorganisms. There may be a selection for those species which can decay the unique organic compounds (xenobiotic) applied. These organisms will aid in the decomposition of the herbicides but also could possibly form degradation compounds which are toxic.

5. 2, 4-D and 2, 4, 5-T have been used as herbicides and plant growth regulators for 40 years. If essential combination of microflora are present 2, 4-D and 2, 4, 5-T are fairly quickly degraded to non-toxic products.

However, picloram is more stable in soil, being detectable for up to 3 years. Arsenic from cacodylic acid may remain in soil in a fixed condition. Decomposition rates of pesticides in soil will vary depending upon soil physical properties, acidity, microflora composition, and adherence to clays.

One study reported long time persistence of herbicides based upon phenol analysed. This persistence may be related to fixation in soil organic matter or clay minerals in the soil.

RECOMMENDATION

Our group makes these final proposals for international long-term cooperation of interested scientists:

1. Total ecosystem studies are needed to understand the role of herbicides and pesticides (xenobiotics) in geochemical cycling and their effects upon soil fertility.

2. A survey should be made of land use in herbicide-treated areas and the resulting sequence of vegetation change. The survey should include locations of any areas of intensive land deterioration due to erosion.

3. Techniques of restoration of soils deteriorated by adverse aspects of herbicide use and subsequent land use should be developed and applied. Special attention is needed for acid sulphate soil reclamation.

4. Studies are needed in the persistence of herbicides in soils and their processes of degradation. The role of microorganisms in decomposition and degradation of herbicide materials needs study. Studies of effects upon microfloral composition and selected indices of herbicide presence such as nitrogen fixers, cellulose decomposers and mycorrhizal and plant microflora associates are needed.

5. Studies on special soil topics related to herbicide use are needed such as the possible catalytic effect of clay minerals on photo-oxydation and degradation of herbicides, and the effects of herbicides on processes of soil laterization.

6. Studies should be made on persistence of dioxin contaminants of herbicides in soil and their possible movement in the food chain to man.

7. We recommend that international organizations (UNESCO, UNEP, UNDP, FAO...) and the international scientific community help in collaboration with Vietnamese scientists in the studies of these problems associated with the use of herbicides in the Vietnam war.

We recognize that there are far broader aspects of herbicide use in a global context and that we have confined our discusion to the effects of herbicide use during wartime in Vietnam on soil conditions. Related materials are in the reports of group dealing with agriculture, forestry, mangroves and the chemistry of herbicides.

FINAL SUMMARY REPORT OF WORKING GROUP E 4 ON COASTAL, AQUATIC AND MARINE ECOSYSTEM

During the Second Indochina War, extensive areas of forests were defoliated in the southern part of Vietnam. In particular mangrove forests were periodically defoliated during the period of years between 1961 and 1971 and resulted in the complete destruction of a significant percentage of the forests

in the provinces of Tien Giang, Ben Tre, Cuu Long, Hau Giang, Minh Hai and Ho Chi Minh City (Rung Sat). A U.S. National Academy of Science study team concluded in 1974 that the affected mangrove areas were so intensively damaged that natural recovery might take as long as 100 years, due in part to the loss of seed sources. The destruction at the mangrove forests in the affected provinces resulted in a significant potential loss of timber, firewood, tannin and other forest products and presumably led to a decrease in estuarine and nearshore fishery yields. In essence, a significant percentage of the mangrove ecosystem, including its associated estuarine fauna and flora, experienced a significant productive loss.

The use of defoliants in the upland areas of Vietnam was more extensive, but the subsequent damage was variable compared to that in the mangrove forests. However, the disturbance in the watersheds and the introduction of defoliants into aquatic ecosystems has been associated with aquatic biological changes that are considered to be serious.

This working group on aquatic, coastal and marine ecosystems has reviewed the available information and data and recommends that countries and international organizations supporting the development of the Socialist Republic of Vietnam provide assistance for the: 1) assessment and monitoring of any possible chronic effects, due to residual defoliants, during the process of ecosystem recovery, and 2) the evaluation of productive alternatives for the utilization of the altered habitats for economic and social benefits.

COASTAL MANGROVE ECOSYSTEMS

The data and information that are available for the mangrove ecosystem indicate that the effects of defoliation are long lasting and widespread within the affected areas. The relatively good quality of the available information makes it suitable for the definition of the basic research programs required to assist in the restoration of the habitat, and its fauna and flora, and the directions that should be taken in developing new economic opportunities. The trial plantations of a high-value species of mangrove *(Rhizophora apiculata)* in its former habitat, could accelerate the recovery of the mangrove ecosystem.

However, unsuitable and degraded habitats will require the evaluation and selection of alternative economic uses.

Whereas it is doubtful that toxic residues persist in significant concentrations, there is a reasonable probability that the defoliated and altered watersheds continue to have an impact on the downstream coastal mangrove forests. Altered hydroperiods, excessive erosion and deposition, and introductions of deleterious materials could have a significant effect on the fauna and flora of the mangrove ecosystem and estuarine areas. Insufficient quantitative data exist to assist in evaluating these possible impacts.

INLAND AQUATIC ECOSYSTEMS

Compared to the existing knowledge of the mangrove ecosystem, defoliant effects are reported in

fewer documents for the potentially affected inland aquatic ecosystems. However, some data and informant reports have been assembled by qualified Vietnamese scientists. These suggest that the existence of defoliation induced adverse effects including the loss of freshwater vertebrate and invertebrate species and caused anomalous deformations among species of the local freshwater algae. Because many questions remain to be answered concerning this topic, a statistically valid assessment study is warranted that determines the characteristics of the altered environments and aquatic components, particularly those that have economic importance.

MARINE ECOSYSTEMS

Vietnamese scientists also confirm earlier reports of declining marine fishery stocks and the disappearance of certain species. Although similar problems are being reported in other countries of the region, the Vietnamese situation cannot be attributed to overfishing and related exploitive fishing practices. It is therefore urgent that fishery stock assessments be undertaken and that local training be provided in fishery management and capture techniques.

RECOMMENDATIONS FOR RESEARCH COOPERATION

Due to the ecological and economic value of Vietnam's coastal, aquatic and marine ecosystems and because Vietnam's opportunities for natural resource

development are limited, this working group recommends that:

1. Vietnam participate in UNESCO's Regional Coastal and Marine Programme by creating a Coordinating National Mangrove Committee and sending participants to Bangkok, Thailand, for training in mangrove biology and management. The National Committee should also serve as an ad-hoc advisory body to monitor the reclamation and restoration of altered ecosystems.

2. Vietnam should solicit cooperation with the Czechoslovakian Academy of Sciences concerning the use of indicator species in monitoring the recovery of inland aquatic ecosystems.

3. Vietnamese scientists and natural resource managers should actively solicit library materials, methodological handbooks and training aids on relevant scientific and management subjects.

RECOMMENDATIONS FOR RESTORATION OF NATURAL RESOURCES

1. Vietnam should undertake statistically-controlled studies of each altered ecosystem for the purpose of explaining why certain ecosystems appear to be slow in recovering, to lay a scientific basis for accelerating the recovery processes.

2. Vietnam should evaluate all alternative potential uses of the altered ecosystems, with emphases on aquaculture and the harvesting of species not previously utilized in Vietnam.

3. Vietnam should incorporate socio-economic considerations in its natural resource development plans to ensure that maximum benefits are obtained.

It is necessary to strengthen international cooperation with Vietnamese scientists for effective assistance in overcoming the consequences of the war in Vietnam.

FINAL SUMMARY REPORT OF WORKING GROUP P 1 ON CANCER AND CLINICAL EPIDEMIOLOGY

1. OVERVIEW LITERATURE

TCDD is one of the most toxic organic compounds, producing a wide range of organ and metabolic disfunctions, fetotoxicity, teratogenicity and carcinogenicity at the p.p.t.-p.p.b. range. There is a general consistency between the pattern of chronic toxicity induced in animals by TCDD and TCDD-contaminated chloro-phenolic compounds and those observed in exposed human populations. Such toxicity includes: chronic hepatitis disturbances in immune function and in lipid — and porphyrin metabolism, and neurological abnormalities sometimes associated with a toxic neurasthenic syndrome. Studies by Ton That Tung on herbicide-exposed Vietnamese populations in the Second Indochina War have produced suggestive evidence of an excess

of primary liver cancers and other evidence of chronic toxicity. A series of Swedish epidemiological studies, confirmed by more recent U.S. mortality studies, have demonstrated an excess of soft tissue sarcomas in groups occupationally-exposed to chlorophenoxy herbicides and chlorophenoxy compounds. Chloracne is not an obligate effect of TCDD exposure in either sensitive animal species or in humans.

2. VIETNAMESE AND OTHER DATA

Morbidity studies on civilians in Tay Ninh and Ben Tre and in Vietnamese veterans in the North have demonstrated consistent and strong associations between herbicide-exposure and chronic neurasthenic symptoms. Two preliminary case-control studies of primary liver cancer were reported. A case-control study of primary liver cancer in Hanoi demonstrated a strong association with herbicide-exposure. Another similar study at Cho Ray hospital with a limited number of cases evidenced a slight excess of risk of liver cancer in exposed persons, but this association was not large enough to achieve statistical significance.

3. EVALUATION OF VIETNAMESE DATA

These studies have established suggestive evidence of an association between herbicide-exposure and chronic toxic effects, including neurasthenic symptoms and primary liver cancer. It is planned to expand these studies with particular reference to

the following: definition of past and present exposure to toxic herbicides including dioxin levels from direct and indirect sources; methodological considerations including the need for larger sample sizes, random sampling, the use of multiple controls and avoidance of reporting bias; incorporation of objective clinical and laboratory studies, such as associations between chronic neurasthenic symptoms and disturbances in nerve conduction velocity and lipid — and porphyrin metabolism; and study of the rule of Hepatitis B in studies for the association between primary liver cancer and exposure to toxic herbicides. The working group recognises the major problems in conducting complex epidemiological studies of this type, even under ideal conditions, and congratulates their Vietnamese colleagues for their scientific contributions under difficult conditions.

4. FUTURE SCIENTIFIC COOPERATION

While primary consideration has been directed to Vietnam, the working group recognizes the existence of similar problems and needs in Laos and Kampuchea following the Second Indochina War. Greatly expanded initiatives should be developed in the following general areas: collaborative programs based jointly in Vietnamese and foreign laboratories; visiting consultant programs involving foreign scientists to work in Vietnam; scholarship programs allowing young Vietnamese scientists to receive

specialised training in foreign countries; development of standardized protocols for epidemiological, clinical and laboratory studies; and foreign reference centres for specialised purposes such as TCDD analyses and histopathology review. Attempts should be made to integrate such initiatives with world wide studies on groups occupationally exposed to dioxin and dioxin-contaminated chlorophenoxy compounds, including foreign veterans of the Second Indochina War, and to develop such initiatives in parallel with programs to improve the overall public health and nutritional status of the Vietnamese population. Recommendations for specific collaborative program include expanded case-control studies designed to investigate the relationship between past exposure to toxic herbicides and present disease in standardized populations and also designed to study associations between subjective disease and objective clinical and laboratory findings and to study the relation between such associations and present dioxin levels in soil, water and vegetation of areas exposed to toxic herbicides, retrospective case-control studies on soft tissus sarcoma; and subject to available resources, long-term prospective epidemiological studies on exposed Vietnamese populations.

5. RECOMMENDATIONS FOR PRACTICAL ACTION

The working group recognises that all recommendations are meaningless in the absence of a workable plan for implementation.

The following recommendations are therefore proposed:

1. Funding should be sought to support further research, diagnosis, and treatment of the effects of exposure to herbicides in Vietnam, Kampuchea and Laos.

2. We should immediately establish practical mechanisms for scientific collaboration. In particular, these mechanisms should include international scientific commissions or committees for collaborative research.

3. The participants in this symposium should make every effort to increase the availability of medical supplies to Vietnamese, Lao, and Kampuchean researchers, also scientific journals, laboratory reagents and equipment.

4. Research concerning the treatment of exposed persons should be part of the overall research program.

5. WHO should be approached concerning the expansion of their IARC-dioxin project to incorporate and support herbicide-effects research in Indochina.

FINAL SUMMARY REPORT OF WORKING GROUP P 2 ON REPRODUCTIVE EPIDEMIOLOGY

The working group accepts without dissent the animal evidence proving the teratogenicity of dioxin when administered to females, but remains unaware

of any acceptable evidence of the transmission of this toxicity through the male.

Although there have been many studies of the medical effects of Agent Orange and related compounds, together with their contaminants, they have been inconclusive as regards reproductive effects and therefore the study of these in Vietnam, where there has been such extensive exposure, seems to be of the greatest interest and importance, not only to Vietnam but also to the rest of the world.

Recognizing, and indeed deeply cognizant, of the extraordinary difficulties necessarily associated with any such retrospective study, especially when it is being carried out some 15 years after the time of exposure, we have been very much impressed by the seven Vietnamese studies that have been reported to us. These evaluations of the possible teratogenic and/or mutagenic effects of herbicide-exposure are being made in three major ways:

1. Changes in the frequency of miscarriages and stillbirths relative to normal deliveries;

2. Changes in the frequency of congenital malformations;

3. and changes in the rate of occurrence of hydatiform mole.

Changes in miscarriages, stillbirths and congenital anomalies have been studied not only among exposed women (necessarily in the southern part of Vietnam) but also in the children of unexposed women whose husbands have been exposed.

The authors of all these investigations, well aware of the many obstacles to a completely satisfactory

study, have proffered them as preliminary reports even when they already include an immense amount of laboriously acquired information.

The most complete, and perhaps consequently the most impressive and persuasive studies, relate to an increase in the unfavorable outcomes of pregnancy in North Vietnamese women whose husbands served in the South and were therefore at least potentially exposed to herbicides compared to fellow villagers whose husbands had stayed in the North. Providing the following criteria have indeed been met : a properly carried out blind study, an absence of bias (especially in selection) maximum validation of data other than by self-reporting, and strict adherence to the properly prepared protocol (and we have no specific reason to doubt any of them). Then a statistically valid increase in these unfavorable outcomes has been shown for the wives of exposed fathers in one study and strongly suggested in another which additionally indicates a reversal of the usual increase in the frequency of such disasters with progressive pregnancies.

However, it is agreed by all that in such investigations, especially when they show results contrary to previous experimental evidence, one or even two or three congruent investigations are not enough to provide complete proof of their conclusions, and further similar work is needed.

As regards congenital anomalies, there are several studies apparently indicative of a generally higher rate of their frequency among exposed women, but these changes are often hard to prove beyond any doubt. The absolute rate of reported congenital

anomalies in Vietnam seems generally very low. Although the reasons for this are not fully understood, they may include the low sensitivity of the information system, reduced exposure to toxic chemicals and inherent ethnic differences.

We are much impressed by the large number of reported cases of the following categories of congenital anomalies:

1. Anencephaly and other neural tube defects, which in this case are associated with a remarkably low incidence of spina bifida;

2. Deformities of the sense organs such as anophthalmia;

3. Deformities of the limbs including phocomelia;

4. Conjoined twins;

5. Orofacial cleft defects.

In most other countries these malformations are either not very common (anencephaly, orofacial clefts) or even rare (deformities of limbs, anomalies of sensory organs and conjoined twins).

In order to appropriately further pursue this important field of inquiry, at least two things are essential: a more precise identification and classification of reported anomalies, and a determination of the expected rate of such deformities in Vietnam either by the recovery of accurate pre-spraying figures or, second-best, the use of data from closely related populations available through WHO for the years 1962-1963 for India, Hong Kong, Malaysia and Singapore, or, minimally, by determination of the worldwide reported range of frequency.

Hydatiform moles again seem to show an increase in frequency in exposed women but more work is needed if this is to be proved. Recognizing the relatively high frequency of this lesion in Southeast Asia, information should be obtained as to any recent changes reported elsewhere in the area.

We feel that the general design of the studies reported is excellent but that additional numbers are needed, controls made somewhat stricter, possible variables carefully scrutinized and protocols rigidly adhered to. Until now exposure index has rarely been included and no sort of dose-response curve has been constructed. Consideration should be given to comparing the possible results of direct exposure compared to exposure via the diet. Search should perhaps be made for other possible toxins such as heavy metals or DDT.

Finally we would point out that even if all of these studies, as designed, were to yield unequivocally positive results even then only the increased defects resulting from exposure would have been proved, not the specific association with dioxin, which would remain presumptive until the causal relationship was confirmed by separate investigations. These would be made easier if the newest methods of chemical analysis can, indeed, still demonstrate residual dioxin at variable levels in human tissue.

The group agrees that the remaining problems of the possible teratogenesis of herbicides requires ex-

tensive continued study by the scientists of Vietnam in which they could be appropriately aided by the international community, especially with respect to laboratory experimental investigations.

FINAL SUMMARY REPORT OF WORKING GROUP P 3 ON EXPERIMENTAL TOXICOLOGY AND CHEMISTRY

(including Cytogenetics, Dioxin and Related Chemistry)

CHEMISTRY

Chemical warfare agents of the herbicide and defoliant category were used in South Vietnam between 1961 and 1975 and on a massive scale in the mid to late 60's. A diverse group of chemicals was used including Agent Orange and its analogs, as well as Agents White and Blue.

According to the US National Academy of Sciences the quantity of herbicides and defoliants used in Vietnam was about 90,000 tonnes. A. H. Westing has also reported a similar tonnage. Vietnamese scientists, however, believe that the quantity used was greater than this and that the amount exceeded 100,000 tonnes. This higher estimate includes harrassing agents such as CS.

All of the chemical warfare agents used were sprayed over an area of approximately 38,000 square kilometers. The concentration of chemicals used varied from between 15 -20 kg/hectare to 300kg/hectare in unusual circumstances (average about 30 kg/ha). Agent Orange and its analogs made up approximately 80% of the herbicides and defoliants employed in South Vietnam. Agent Orange and its analogs contained the highly toxic contaminant 2, 3, 7, 8-tetrachloro-dibenzo-para-dioxin (TCDD). According to official US figures quoted by A. H. Westing approximately 57,000 tonnes of Agent Orange and its analogs were sprayed and this quantity of herbicide contained not less than 170kg of TCDD. Some participants of the working group agreed with this figure, but a majority came to the conclusion based on some published data — that the total amount of TCDD sprayed over Vietnam was greater than 500kg.

Some delegates did not agree with this assumption. Based on analytical data from samples left over from the spraying program in Vietnam and the amounts of 2, 4, 5-T produced in different factories, in different years, and subsequently sprayed, they arrived at a total figure of about 170kg.

Due to the high toxicity of 2, 3, 7, 8-TCDD and the large variation in toxicity between different isomers the analytical method used in dioxin analysis should have good reproducibility, a very high sensitivity (in the 10^{-12} g'range) and they should allow the quantification of specific isomers, especially the 2, 3, 7, 8-TCDD isomer.

To date 2, 3, 7, 8-TCDD has been found in several different types of samples like formulations, soil, sediment, vegetation, fish and animal tissue, bovine and human milk, human blood, liver, kidney and adipose tissue.

Although 2, 3, 7, 8-TCDD is the major impurity found in Agent Orange, it should be pointed out that other dioxins such as 1, 3, 7, 8-and 1, 3, 6, 8-TCDD; 1, 3, 7-tri-CDD; 2, 7-and 2, 8-di-CDD have also been reported together with a series of dibenzofurans.

TCDDs have also been found in other technical products. Of special interest is the existence of 1000 ppm of TCDDs in diphenyl ether herbicides used in ricefields. The major isomers are 1, 3, 6, 8- and 1, 3, 7, 9-TCDD but other isomers have also been identified; however, 2, 3, 7, 8-TCDD has not been found. Secondary formation of TCDD after spraying has also been discussed (photochemical and pyrolytic formation). The ecological situation is very complex, however experimental data do not indicate any extensive secondary formation of the dioxin. Burning of 2, 4, 5-T salts results in high yields of TCDD.

A series of experiments have demonstrated the bioavailability of TCDD in soil and sediments. It is therefore recommended that tissue samples from both aquatic and non-aquatic animals should be analysed for TCDD.

The degradation of TCDD in soil is very slow, a half-life of greater than 10 years has been reported. The metabolism excretion of TCDD

from primates seems to be quite slow with a half-life of about 1 year. In small rodents the degradation is reported to be much faster.

Analysis of the parent phenoxy herbicide (2, 4, 5-T. 2, 4-D) in various samples can be done by standard methods (HRGC), however the presence of trace levels should be confirmed by an additional technique, e. g. mass spectroscopy.

For the analysis of arsenic atomic absorption and X-ray spectroscopy are the methods with the best sensitivity and reproducibility.

RECOMMENDATIONS

The working group recognized two analytical studies of samples from Vietnam. In fish samples from the early 70's Baughman found up to 800 ppt of TCDD. In a recent study Olie identified small amounts (up to 30 ppt) in soil and sediment samples from Vietnam. The working group recommends further research on critical samples like soil, sediments, fish and other aquatic animals, human milk and human tissue samples. The first phase of such a project should include a brief screening of "grab samples" followed by systematic sampling in the presence of international organizations like UNESCO and/or UNEP. After coding the samples together with control samples should be sent in a "round robin" study to different laboratories, e. g.

- ★ Amsterdam
- ★ Hanoi, Ho Chi Minh City
- ★ Lincoln, Nebraska
- ★ Moscow
- ★ Umea, Sweden

GENETIC EFFECTS OF HERBICIDES

Vietnamese scientists using standard non-banding cytogenetic techniques and sister chromatid exchange methods for investigations on chromosome aberrations have reported an increase in chromosome aberrations and sister chromatid exchange on adults and their children directly exposed to herbicides in South Vietnam. These people are still living in the sprayed area. A control group was selected from South Vietnam.

The abnormalities reported include chromatid breaks, chromosome breaks, translocations and polyploid cells. Some of these are rarely seen in human beings, especially ring chromosomes, translocations with quadriradial figures, and endoreduplications. The above-mentioned genetic aberrations have been found many years after the chemicals had been sprayed. According to the Vietnamese scientists similar aberrations have been reported for victims of radiation exposure in Japan following the dropping of atomic bombs. And the Vietnamese scientists believe that their findings indicate that there has been a long-term health effect on the victims of herbicide exposure.

The above information has been extended by other Vietnamese scientists who reported an increase of chromosome aberrations on spermatogonia and primary spermatocytes caused by 2, 4, 5-T in *in vivo* tests on the white mouse (Mus musculus).

Delegates discussed papers indicating absence of mutagenicity in Drosophila (fruit flies) and absence of mutations for dioxins in the bacterial Ames test,

but the presence of mutations when dioxin was tested in a mammalian cell transformation assay.

Comments on findings of Vietnamese scientists. In the opinion of the group the work of the Vietnamese scientists is interesting, but because of the controversial nature of the published literature on genetic effects of these herbicides further studies by additional laboratories are needed.

CARCINOGENICITY

One delegate presented evidence on the carcinogenicity of 2, 3, 7, 8-tetrachlorodibenzo-p-dioxin (dioxin) in rodents. The paper considered alongside the 5 already published in the scientific literature indicates that there is now sufficient evidence to class dioxin as a carcinogen in a number of animal species. It is not yet clear, however, whether dioxin acts directly or indirectly to cause cancer. However, the work presented in the group on the mutagenicity of dioxin in a cell transformation assay suggests that this chemical is an initiator and can cause cancer. Evidence was also presented for the carcinogenicity of the herbicide 2, 4, 5-triclorophenoxyethanol in rodents.

TOXICOLOGY

One delegate presented evidence for the toxicity of herbicides (2, 4-D and 2, 4, 5-T) in fruit flies at 1000 ppm and 300 ppm respectively. The toxic effects included total failure of the life cycle of the fly at these doses, and proportionate survival at lower doses with a developmental delay which was not teratogenic, but which caused changes in the duration of the life cycle, the sex ratio of the

emergent population, and the time of maturation of the flies. It also included behavioural modifications in the choice of media for egg laying. Media without herbicide were preferred for egg laying over those with either 2, 4-D or 2, 4, 5-T, or a mixture of these (The dioxin content of the 2, 4, 5-T tested is not known). Two other delegates reviewed the scientific evidence on the cytotoxic effects of halogenated hydrocarbons and on the toxicity (including delayed toxic effects) of chemical warfare agents in genernal.

The mode of action of the chlorinated pesticides, polychlorinated dibenzofurans and dioxins was discussed with reference to their action in the liver. Chemical warfare agents were reported to have delayed toxic effects in humans and it was recommended that a considerable research effort was required to find out more about this problem. In particular, it was suggested that workers employed in the manufacture of chemical weapons be studied for any long-term health problems.

RECOMMENDATIONS

We would like to see:

1. more *in vitro* studies using eukaryotic organisms with different doses of herbicides to determine different frequencies of chromosome aberrations and gene mutations.

2. Continued monitoring of the population exposed to herbicides to detect any mutagenic and carcinogenic effects in this, and subsequent generations.

3. Cooperation between laboratories on an international basis to facilitate this work.

THE LASTING CONSEQUENCES OF CHEMICAL WARFARE

Dr. Nguyen Khac Vien

In 1961, for the first time in the history of mankind, large-scale chemical warfare was started in South Vietnam by the Kennedy Administration. Massive sprayings of so-called defoliants were carried out by the U.S. Army between 1961 and 1971, mainly in 1967-70, then sprayings were carried on by the Saigon army, on a lesser scale, until 1975.

Here are the estimates of the American biologist Arthur H. Westing:

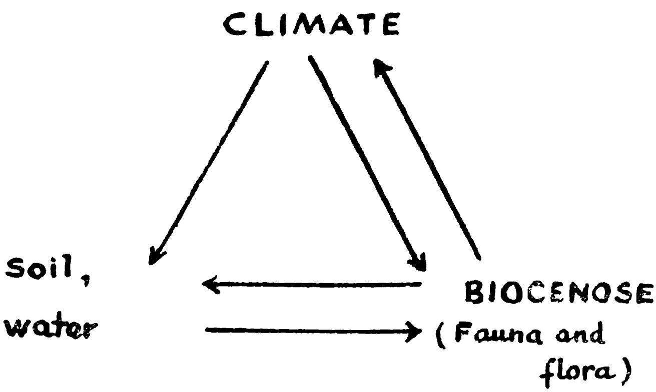
— 44,300 cubic metres, i.e. 57 million kilograms of Agent Orange were used.

— This quantity of Agent Orange means that South Vietnam received 170 kilograms of dioxin.

(*Nature*, London, 298 (5870) : **114**, 8-7-1982)

American biologists were the first to point to the serious consequences of chemical warfare on the vegetal environment. And as early as 1970, at a scientific conference held in Orsay, France, Vietnamese Professor Ton That Tung laid stress on the mutagenic effect of dioxin on chromosomes, its

carcinogenic effect, and posed the problem of the correlation between chemical warfare and the increase in the rate of primitive liver cancer in Vietnam. Chromosomic aberrations were detected in people who had stayed in contaminated regions. Ecological consequences were studied, by American biologists Westing and Pfeiffer in particular and although thorough surveys were not possible due to wartime conditions long before the war ended, distressing questions were already being asked. The classical diagram of the "ecological triangle" is well known:



Abruptly changing conditions in the biocenose has an effect on the soil and climate, which will produce changes affecting the fauna and flora and human life.

The consequences of this chain of reactions cannot be predicted. In the long run what are the effects of those massive sprayings of toxic chemicals — on the natural milieu, the ecological environment of Vietnam?

— on the health of the Vietnamese population, given the carcinogenic, teratogenic and mutagenic effect of dioxin, at present and in the future?

For Vietnam the problem assumes an immense importance. And so, in spite of major obstacles — shortage of technical and financial means; difficulties encountered in conducting analyses requiring high technology — Vietnamese biologists and medical doctors have made great efforts in the last few years in studying the lasting consequences of this war in order to lay the groundwork for future large-scale and long-term action.

The accident in Seveso, Italy, and the claims made by American and Australian veterans of the Vietnam war who were subjected to the action of those chemicals have attracted renewed public attention in the West to the problem.

Below are some concrete data on the persisting sequels of that chemical war.

PART ONE

DESTRUCTION OF THE NATURAL ENVIRONMENT

Chemical warfare aimed at

— destroying those areas of forest and brush which could serve as refuges for guerillas: it was the anti-guerilla weapon *par excellence;*

— destroying food crops and making life impossible for the peasants: defoliation was one

of the main elements of the strategy of "forced urbanization" which would empty the rural areas of their inhabitants and strike at the root of national resistance.

The British Major Thompson, who had directed the war against Malay insurgents and later became an adviser for the Pentagon, wrote that guerilla warfare would be impossible in a desert. So turn Vietnam, a tropical country with a luxuriant vegetation, into a desert!

It should not be forgotten that the massive sprayings of chemicals were preceded or accompanied by deluges of bombs and shells, incendiary products, napalm, phosphorus bombs, etc. In the Vietnam war, the Americans dropped 15 million tons of ordnance, that is more than three times the tonnage dropped on all theatres of operations during the Second World War. Two-thirds of the villages and hamlets of South Vietnam were either destroyed or heavily damaged. Ten million people were driven from their native regions to the towns and cities or to regroupment centres.

One must keep in mind this total war in order to grasp the serious effects of the chemical war studied hereinafter.

GENERAL DATA

The most often used defoliant was so-called Agent Orange, which is a butylesteric mixture of 2, 4-D (dichlorophenoxyacetic acid) and 2, 4, 5-T (trichlorophenoxyacetic acid) with a residual substance, TCDD, 2, 3, 7, 8, tetrachloro-dibenzo-para-dioxin, dioxin for short.

EFFECTS ON FORESTS

The effects of defoliants are immediate: fall of leaves, drying up of trunks, loss of crops, death of plants, insects, fish and other animals.

Long-term effects:

— erosion of the soil by tropical downpours, aggravated by the disappearance of the foliar cover; impoverishment of the soil in organic matter, nitrogen and other elements; laterization Persistence for long years of products resulting from the degradation of defoliants: organic arsenic, chlorophenol, substances harmful to plants and man. As recently as 1981, they were still detected in many soil samples.

— alteration of the vegetal cover through disappearance of natural vegetation which is replaced by a poorer secondary vegetation. Rich forests are often replaced by a savanna of tough grass (*Imperata cylindrica)*;

— direct action by chemicals or action following bio-degradation, on soil micro-organisms, plants, insects and other animals, leading to considerable modifications in the food chains of various species and compelling some to leave the contaminated areas for good;

— extension of noxious effects far beyond the sprayed areas through the washing away of defoliants and their degradation-related products by running water;

— in the dry season, which lasts many months, the secondary vegetation is highly susceptible to fire following the disappearance of the thick foliage

cover protecting the soil. Only grasses with intertwined and resistant rhizomes can survive.

— natural regeneration is impossible and artificial reafforestation has proved in experiments to be very costly and to take a long time.

— leeches, mosquitoes and flies, after completely disappearing, reappear in large numbers. Honey-bees are permanently destroyed. Fish, frogs, snakes, and birds quickly vanish; many wildlife species (boars, deer, bears, tigers) die or are forced to leave the area for lack of food, while rodents thrive, hence the outbreak of certain epidemics e.g. plague;

— the disappearance of the vegetal cover over large areas brings about important climatic changes: greater differences in temperature between seasons, between day and night and aggravated evaporation on land stripped of vegetation.

The damp tropical forest, an ecosystem very rich in animal and vegetal species and with a high productivity, usually offers effective resistance to cyclical climatic changes or local perturbations. But chemical warfare, by brutally destroying important factors for equilibrium, often leads to its definitive disappearance when massive sprayings are carried out repeatedly and when the soil shows a steep gradient.

ON CROPS

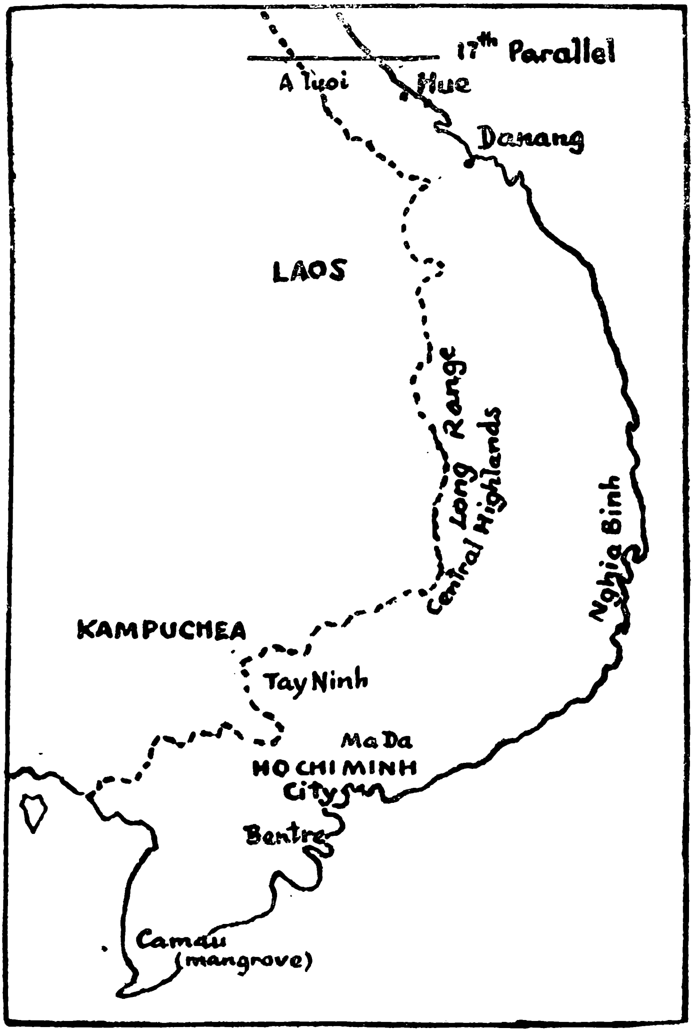
All vegetal groups are affected, all forms of plantation, and at all stages of growth. Stems, branches, leaves, flowers, fruit lose their colours and become deformed and brittle. Germination and growth are hampered. Finally, the plants wither

and die. Effects vary according to the products used, atmospheric conditions, soil qualities, the resistance offered by each species, but because of the high concentrations used during the war — often a hundred times as high as those used in agriculture — all species are affected.

Plants no longer produce fruit; affected fruit and tubers are spoilt and can no longer be consumed. Total nitrogen percentage in rice goes down from 1.16% to 0.98%; in maize from 1.14% to 0.74%. The amount of starch also diminishes, from 60.77% to 57.07% for maize, from 70.98% to 66.21% for rice. In the tubers of sweet potato and cassava, proteic nitrogen disappears almost completely. Biochemical modifications in fruits are also considerable.

Defoliants affect enzymatic processes, hamper the metabolism of reserve products in fruits and tubers, reduce their nutritive qualities, lessen their resistance to micro-organisms. Substances are formed which taste bad and cause gastro-intestinal disorders. Cattle, pigs and poultry eating contaminated feed are poisoned.

On contaminated soils, seeds cannot sprout for weeks, and for months after, germination is still slowed down or hindered. Some seedlings die soon after germination. After a spraying, there is quick diminution of the number of micro-organisms in the soil. Agent Orange also hampers the growth of fungi of the *Aspergillus* and *Trichoderma* groups. Over large areas, the biological population is greatly diminished in both quantity and quality and the ecological equilibrium is destroyed for a long time.



SOUTH VIETNAM

Regions where ecological and epidemiological investigations have been conducted

Here are some concrete cases.

THE MA DA FOREST

This damp tropical forest located 100 kilometres northeast of Ho Chi Minh City covers about 30,000 hectares of rolling hills averaging 120 metres in height and with gentle gradients (less than 15%). Annual precipitation: 2,185 millimetres. Average temperature: between 23 and 27 degrees Celsius throughout the year. The soil is clayish schist. Given the very sparse population the forest was not subject to exploitation.

This was a rich tropical forest with the dominant canopy made up of *Dipterocarpacae* which can grow as high as 40 metres and whose trunks can be as much as two metres across. The forest was a three-tiered one which could yield up to 200 cubic metres of timber per hectare. Many wild animals lived there: elephants, tigers, panthers, bears, deer, roe deer, pythons, a wide variety of other snakes, as well as swarms of honeybees. Many species of medicinal plants which could be used in traditional pharmacology grew there.

Massive sprayings of defoliants were conducted between 1967 and 1969 seriously affecting about 5,000 hectares. The *Dipterocarpacae* and *Leguminosae* quickly withered. This was immediately followed by a rapid development of *Imperata cylindrica* and *Pennisetum polystachyum* grasses. When the dry season came bombardments by artillery and rockets set them afire, destroying what remained of the underbrush and the shoots of such valuable species as *Dalbergia cochinchinensis*

together with some *Sapindacae* grown from seeds coming from surrounding areas.

All that remains now is a vast stretch of savanna of *Imperata cylindrica* and *Pennisetum polystachyum* with some worthless shrubs.

In less affected areas, many species of the dominant canopy disappeared. Only about 25% remain but their crowns are either gone or attacked by insects and various germs. At present 74% of the Ma Da forest is either savanna, or clusters of degenerate bamboos, or sparse groves of quick-growth species. Valuable species, those bearing latex or oleoresins and with tall foliages, were the first to be affected. Birds and other animals have become quite rare.

Twenty percent of the area could go through a process of natural restoration but the rest must be reafforested. As early as 1978, a State enterprise began working on the savanna tracts planting such forest species as *Tectonia grandis, Eucalyptus camaldulensis, Dipterocarpus dyeri...* but dry-season fires ravaged the plantations and soil laterization hampered plant growth. To cope with these difficulties, there has been recourse to a preliminary plantation of *Acacia ameura* for environmental improvement, but this has proved to be costly in time and money.

The same observations can be made about the former military zones C and D in Song Be and Tay Ninh provinces where large-scale military operations took place mostly between 1965 and 1972. (Operations Cedar Fall and Junction City). Massive

sprayings of defoliants were followed by intensive aerial bombings, artillery shellings and the razing of villages and fields by giant bulldozers (« Roman ploughs »).

In those regions were high-productivity forest ecosystems, essentially made up of *Dipterocarpacae* which could grow as high as 80 metres and with a density of 200-300 trees per hectare and of endemic *Leguminosae* yielding wood for luxury furniture fetching high prices on international markets.

Together with the total destruction of the damp tropical forest and its replacement by a secondary bush with species of little value, or savanna and bamboo thickets, there have also been disastrous hydrological consequences. Because those forests grew on the slopes of important river basins (Dong Nai, Song Be and Saigon rivers) there has been a worsening of floods and droughts for regions in their lower reaches — Ho Chi Minh City and rire-growing provinces in the Mekong delta.

Reafforestation has proved to be a difficult undertaking. Important capital investments have been made to plant rubber on those tracts but judicious and expensive technical arrangements are called for. Experiments have been conducted with a view to recreating a type of multi-tiered damp tropical forest with many species and serving several purposes :

— a canopy of tall *Dipterocarpacae* ;

— a tier of continuous foliage with *Leguminosae* ;

— an underbrush for paper pulp and fuel ;

— herbaceous vegetation and medicinal plants.

Experiments have shown that the proper forest environment should first be restored with the planting of nitrogen-fixing *Leguminosae (Cassia, Indigofera, Taphosia, Leucanea)* on *Imperata savanna* in particular and on areas stripped of vegetation.

THE CA MAU MANGROVE FOREST

One of the favourite targets of chemical warfare was the mangrove forest of the Mekong delta. It grows along the coast on alluvial land bathed by salt water. About 100,000 hectares were affected, of which 45,000 hectares in Ca Mau very seriously. In this region siltation by the Mekong forms new land in a south-western direction, adding about 60 metres each year to the Ca Mau tip.

Vegetation growing on this land helps the silting process. Growing on mud bathed in salt water with little oxygen, the plants form a peculiar ecosystem where a varied fauna lives. Vietnamese biologists have counted 43 different vegetal species not including algae — almost the totality of species living in Southeast Asian mangroves.

The dominant species is *Rhizophora spiculata* whose prop roots form a kind of scaffolding a few metres high from which the trunk may rise to 20-30 metres. It gives timber for the building of houses, boat, and for joinery and cabinet-making. Saigon used to be supplied with charcoal made in this region. Tannin is obtained from the bark of the tree. Each hectare yields about 100 cubic metres of timber a year.

The first species to grow on the new land is *Avicenna alba,* which forms homogeneous forests. Then, as the soil is consolidated, comes *Rhizophora* which evicts *Avicenna* and eventually occupies 60-80% of the land. In the shadow of *Rhizophora* lives *Ceriops decandra.* Further inland, on the fringe of swamps, the vegetation is more varied.

In this mangrove forest an abundant fauna dwells: tigers, crocodiles, boars, a wide variety of fish, shrimps and birds. The brackish water circulating among the prop roots of *Rhizophora* and filled with all kinds of rotting vegetal and animal debris is a veritable fishpond. With only rudimentary fishing gear, local fishermen take a 200-kilogram catch each night on an average. Birds, wading birds in particular, live in large groups numbering tens of thousands. Logging, charcoal making, fishing, bird catching, not to mention the collecting of honey from the innumerable beehives of the forest, supplied the local population with comfortable incomes.

With the alluvial deposits the land gains on the sea and the ecosystem is repeated. Inland areas are cleared by man. People live mostly in houses on stilts along the rivers and channels crisscrossing the region.

In spite of the absence of declivity, a high degree of humidity and the ebb and flow of the tide, the massive and repeated sprayings of defoliants had particularly noxious and durable effects. The loss of the vegetal cover worsened erosion by rainwater along the canals, which were

silted up. The ecological system was deeply changed.

In the first years, putrefied substances from destroyed leaves and plants accumulated, causing a lessening of the oxygen content of water and a sharp diminution of the number of living organisms. A few years later, those products were mineralized and absorbed by living organisms. The environment became cleaner but the number of fish, shrimps and crabs had decreased greatly. In some places the catch was a mere 10 — 15% of what it used to be. Loss in timber amounted to millions of cubic metres, for *Rhizophora* alone. The larger animals and birds had decreased considerably in number, or even completely vanished for some species. Soil analyses show large modifications in the content of total nitrogen and in Mg, Fe, Al, Ca cations.

At present, about 30% of the area is still without vegetation — far more than American biologists had thought. Several regions have regained their vegetal cover, but with significant modifications. Those parts that are submerged only by very high tides see their soil hardened and with a higher degree of salinity. Here *Rhizophora* gives way to *Phoenix paludosa*. Where the soil is regularly submerged by tidal water, *Avicenna alba* reappears, followed by *Rhizophora* which will be dominant in about fifteen years' time. Further inland, both plants are replaced by *Ceriops*. On those affected tracts extending between untouched forests, from which seeds can come, favourable conditions exist for the natural regeneration of *Rhizophora*, which by now have risen to 6 — 10 metres in height on about 10%

of the total area. High-lying grounds, formerly covered by such species as *Bruguiera parviflora*, were exposed to the sun following defoliation and have become very saline. No tree or plant can grow there.

Since liberation in 1975, an intensive programme of regeneration has got underway. Within the space of six years, more than 20,000 hectares of *Rhizophora* have been revived in Minh Hai province. Work, however, has been hampered by the lack of capital and equipment for many canals have to be dredged or dug, many swamps drained, and large staff needs to be maintained. At first the population tried to grow soya. For two years, the yields were satisfactory, but the absence of a vegetal cover caused desiccation of the soil with attendant increased salinity. Finally the attempt had to be given up. The main objective remains the artificial regeneration of the mangrove forest and the return of the rich ecological system which characterizes it — a long haul indeed.

THE A LUOI REGION

Lying close to the 17th parallel and Highway 9 in an area which saw fierce fighting, A Luoi suffered greatly from the war. For years bombs, shells and defoliants were poured on this region which straddled roads leading from north to south Vietnam and from Vietnam to Laos. It is a valley 30 kilometres long, 2 — 6 kilometres wide, at an altitude of 600 metres, a part of the long Truong

Son mountain range running west of the whole of central Vietnam. Although precipitation is 3,500mm. per year, there is a dry season.

Conditions of soil and climate give rise to a rich biocenose which comprises a great variety of animal and vegetal species. The damp, sempervivens, tropical forest includes several tiers: tall trees yielding valuable timber, 20 — 30 metres high, such as *Podocarpus impricatus*, *Dacrydium pierrei*, *Dipterocarpus turbinatus*, etc. which provide a canopy of foliage and a timber reserve of about 300 cubic metres per hectare. The lower tier is made up of smaller trees such as *Calamus rodentum*, *Dendrocalamus sp*... and at the bottom a herbaceous layer.

Now, as a result of 15 years of defoliant spraying the region has a sinister look: bare stumps of the trees which have died, and in their place, stunted brush, herbaceous plants with serrated leaves, proliferous roots and robust rhizomes like *Thysanolanae maxima*, *Miscanthus arundinaceum*, 3 — 4 metres tall; here and there a bushy vegetation of *Rhodoirtus tomentosa*, *Melastoma candidus*... Down in the valleys grow shorter grasses, hydrophilic and heat-resistant. As in the case of Ma Da, those species which reappear are those which thrive in light, can endure a harsh climate and survive in the aftermath of fires. The proliferation of those herbaceous species prevents the regeneration of the others. As elsewhere, the soil thus exposed and washed by abundant rains and subjected to intense evaporation in the dry season undergoes considerable modifications. And as elsewhere, biologists have

noted important changes in the mineral and organic contents of the soil (total nitrogen, Fe, Mg, Ca...)

The destruction of the fauna was especially spectacular in A Luoi. There used to live 150 animal species, among them 40 kinds of wild beasts: *Panthera tigris, Elephas indicus, Bos gaurus, Neofelis nebulosa*... and a large number of deer, monkeys, etc. The streams and ponds teemed with fish and the forests with birds.

Following the sprayings, dead bodies of deer, foxes and wild dogs, which had died from hunger or from poisonous substances were found in the denuded forests. Dead fish, shrimps and other aquatic animals floated on the surface of rivers and ponds.

At present, only 21 kinds of large-sized birds of prey are found there. All have come from other regions and no regional species have survived. There are no fruit or insects to feed the birds. In August 1981, in the midst of summer, a team of researchers working a whole night caught only a few insects belonging to ten different species; in the ponds and rivers they found only three kinds of frogs. Researchers counted 191 kinds of algae, one-third less than previously. One-sixth of the algae collected presented malformations, a much higher proportion than in unaffected regions. The plankton had greatly declined.

Aquatic invertebrates has diminished in both number and variety, especially *Mollusca, Rotatoria, Cladocera*. No larvae of *Chironomidae, Oligochaeta* and *Potamidae Urionidae* were found. There remained very few species of local fish and some had to be brought in from other regions.

In 1981, no sizable mammal of any value was found while in the neighbouring regions, which had not been sprayed, about fifty species were counted: deer, boars, flying squirrels, bears, wild cats... All those species which used to live in the higher tiers of the forest and those feeding on fruit and leaves had died or left. The stunted and herbaceous growth suited only the small rodents, which thrived as a result of the disappearance of the big carnivores, with serious economic consequences and the increased risk of an outbreak of plague.

The local people used to own a large number of cattle (buffaloes and oxen), pigs and also elephants for portage. All of them had disappeared by 1968. In 1975, stock had to be brought in from the North to regenerate the herd. It is estimated that tens of thousands of head of cattle have been lost. The region, which used to sell cattle to others, now has to buy from them.

The regeneration of the flora and fauna has proved to be well-nigh impossible. At any rate it will call for immense efforts and a very long time.

PART TWO

DIOXIN AND MAN

The problem of the action of chemicals, medicaments, pesticides and industrial products on human health is a burning topic. Many experiments con-

ducted in laboratories and clinical observations have shown that a large number of chemical products have mutagenic, teratogenic and carcinogenic effects. The defoliants used in chemical warfare in Vietnam at exceptionally high concentrations immediately attracted the attention of physicians and biologists to their possible effect on the health of the population.

So long as the war lasted any systematic research in the theatre of operations itself was out of the question. Only some observations were made on people who had lived in contaminated areas in South Vietnam and suffered various ailments and had been evacuated to the North for medical treatment. As we said earlier in this report, as early as 1970, Vietnamese doctors noted the existence of chromosomic aberrations in exposed subjects and a disquieting increase in the number of primitive cancer of the liver, congenital malformations and abnormal pregnancies which seemed to be related to defoliant sprayings.

After 1975, more thorough surveys, especially from the epidemiological point of view, were conducted in the South as well as the North, on people having lived in sprayed areas in the South and on people from the North who had lived or fought in those regions during the war and had later returned home. Check groups in both North and South, composed of people who had never been exposed to defoliants or other chemicals such as pesticides or to various radiations, helped control the results. This was difficult research work which called for sophisticated techniques and abundant

material if significant results were to be gathered. This means that the research work so far conducted in a country which has suffered from decades of war must be carried on with ever closer international cooperation. The results collected so far, however, have great value for the facts observed are often significant enough for relatively well-founded conclusions to be drawn from them.

We shall give below the results of studies conducted in the following fields:

— The mutagenic effects of defoliants (dioxin);
— The teratogenic effects: abnormal pregnancies, malformations;
— The carcinogenic effects;
— Effects on general pathology.

CHROMOSOMIC ALTERATIONS

It was in the Hematology Department of Bach Mai Hospital in Hanoi (the laboratory was destroyed by American bombs in late 1972) that chromosomic alterations were detected for the first time in subjects having stayed for a long time in defoliant-sprayed regions. The study was resumed on a larger scale after 1975 and confirmed the results obtained. Research was conducted in various areas of South Vietnam (Quang Nam, Nghia Binh, Ben Tre, Dong Nai) on direct victims of sprayings or on children born of mothers having lived in sprayed regions. Check groups included people living in areas in the

South with similar ecological conditions but not affected by sprayings, and people living in the North.

It is known that chromosomic anomalies are provoked by radiation and some chemicals. A report by Dr Bach Quoc Tuyen, a hematologist, says:

The study of caryotypes (chromosomic dispositions) of affected people shows a very statistically significant rate of anomalies... Besides simple and double breaks, rings, minuscule chromosomes, dicentrics, di-tri-quadri-radial figures have also been observed quite frequently. The anomalies detected present similarities with those observed among people and animals that have been irradiated...

Can defoliants induce lesions in sexual chromosomes and cause them to be transmitted to future generations? Research we have conducted on children born of mothers who had been subjected to sprayings of defoliants long before their pregnancies also shows chromosomic anomalies at statistically significant rates. So far we have not been able to carry out experimental studies on this aspect of the problem of herbicides in the South. But our hypothesis seems to be upheld by the frequency of spontaneous miscarriages and congenital malformations of the kind observed among mothers who have been subjected to radiation or have been using some chemical drugs. Chromosomic aberrations have been found by authors in the majority of aborted foetuses. So there is good reason to think that defoliants not only have noxious effects on the

present generation but also present dangerous consequences for future generations."

In subjects living in the South, Cung Binh Trung also found quantitative chromosomic alterations: the number of altered cells, of cells with more or fewer than 46 chromosomes, of polyploid cells is far superior to the figures found in check groups. He also found morphological and structural alterations in chromosomes gaps, breaks, translation, rings. Similar alterations may be observed in normal subjects but here the frequency of the alterations had increased in a statistically significant manner.

The same author also observed an increased frequency of exchanges of chromatids between two chromosomes, with formation of "four-rayed strands" or "cross-shaped" ones in mother-cells, this frequency being twenty times that found in the check group. As in the case of Hiroshima survivors, the persistence of chromosomic alterations long after the event is a serious danger the existence of abnormal cells is often the harbinger of cancer or leukemia. Chromosomic alterations in the course of foetal development may bring about miscarriages, foetal death or congenital malformations. These alterations in reproductive cells may be transmitted to future generations.

ABNORMAL PREGNANCIES — CONGENITAL MALFORMATIONS

Epidemiological studies on the frequency of abnormal pregnancies and congenital malformations

confirm the hypothesis of the genetic transmission of mutagenic effects of defoliants.

This disturbing frequency was quickly noted by Vietnamese doctors soon after the first defoliant sprayings but systematic studies were only possible after 1975. Here are the results of some of those surveys.

A comparative study was conducted by Dr Ngoc Phuong on three groups:

— in Thanh Phong village, Ben Tre province, in the Mekong delta — a heavily affected locality;

— in the 10th district of Ho Chi Minh City, not directly affected; one group was composed of never-exposed parents and another of parents coming from affected areas.

Frequency rate	Thanh Phong Exposed subjects	10th district	
		Exposed	Not affected
Congenital anomalies	6.49%	16.33%	2.58%
Death in utero	4.72%	1.02%	0.18%
Natural abortion	47.03%	50.00%	21.65%
Molar pregnancy[1]	10.65%	11.22%	2.30%

1. Degenerescence of the chorion in the form of a cyst.

When these figures are compared with the data obtained in an area of the northern delta, not affected by defoliants, we have these results:

Frequency rate	Thanh Phong (South)	My Van (North)
Congenital anomalies	6.49 %	0.45 %
Death in utero	4.72 %	1.91 %
Natural abortion	47.03 %	5.77 %
Molar pregnancy	10.65 %	0.09 %

In several villages of Giong Trom district, also in Ben Tre province, comparison was made between data obtained before the sprayings with those obtained after them and with data from non-affected villages. It was noted that the rate of spontaneous abortions increased after the sprayings and remained high several years later, compared with non-affected villages. So did the frequency of congenital malformations. The same observations were made at the polyclinic in Tay Ninh city on parturient women and patients from a province greatly affected by chemical warfare.

At the obstetric-gynecological clinic of Ho Chi Minh City (former Tu Du hospital) where treatment is given not only to patients residing in the city but also to a large number of difficult or abnormal cases from all provinces of South Vietnam, retrospective research has been conducted on abnormal pregnancies and malformations as far back as 1952 relying on periodical hospital reports and doctoral dissertations. It has been noted that the rate of natural abortions, which was 0.45% in 1952, shot up to 14.58% in 1967 reaching a peak of 18.14% in 1978, then went down to 10.09% in 1981.

The rate of molar pregnancies and chorioepitheliomas (malignant degenerescence of the chorion), 0.78% in 1952, increased steadily after 1960 reaching a peak of 4.19% in 1981. The increase in the frequency of congenital anomalies is less noticeable, yet differences are statistically significant. The rate of abnormal pregnancies and congenital malformations is visibly higher than that found in other countries of Southeast Asia with similar natural and social conditions (Tu Du hospital: 4.6%; Southeast Asia: 0.5%). Figures obtained in North Vietnam are also clearly lower.

In the same hospital, in surveys of subjects exposed to defoliants, a high rate of molar pregnancies, chorioepitheliomas and malformations was noted. In the North, comparative studies were made of figures obtained from parents having lived in affected regions in the South — combatants who returned home in particular — and those from the non-affected local population. For the town of Yen Bai and the village of Quy Mong, the following data were obtained:

1975 – 78	Yen Bai	Quy Mong
Local population	35,000	4,500
Former combatants	700	30
Malformations in local population	15	0
Malformations in groups of combatants	15	9

The malformations observed went from simple anencephalia to that associated with other defects: absence of nose, eyes, ears, hare-lips, shortened limbs; from simple hydrocephalus to associated hydrocephalus; from syndactylism to the absence of some body parts: forearm, upper jaw, abdominal wall... There was also close connection between the frequency of those anomalies and the particular regions where the combatants had lived, which were affected by chemical war to a varying extent.

All studies, conducted either in the South or the North and in many localities, tallied: chemical warfare led to a visible increase in the rate of abnormal pregnancies and congenital malformations in the affected areas, and this action persisted long after the defoliant sprayings.

CARCINOGENIC EFFECTS — EFFECTS ON GENERAL PATHOLOGY

In 1973 Professor Ton That Tung remarked that the frequency of primitive cancer of the liver (PCL) had visibly increased over the past few years. At the Vietnam — GDR Friendship Hospital in Hanoi there were recorded

— from 1955 to 1961, 159 PCL cases out of a total of 5,492 cancer cases;

— from 1962 to 1968, 791 PCL cases out of a total of 7,911 cancer cases.

PCL incidence had thus increased from 2.89% to 9.07%.

Since then a survey has been conducted in order to find the relationship between this rising PCL incidence and the start of chemical war. Many experiments have indeed highlighted the carcinogenic effect of dioxin at infinitesimal doses (especially experiments on rats conducted for the firm Dow Chemical). The cancer research group (CRG) of the agency for the protection of the environment holds that the carcinogenic effect of dioxin is several times superior to that of other chemicals such as aflatoxin.

Studies made over the last few years in Vietnam have shown that PCL incidence is five times higher in subjects exposed to defoliant sprayings than in non-exposed subjects. No definitive conclusions have so far been drawn by Vietnamese doctors because of the limited number of cases studied.

However, there is strong reason to think that dioxin is a possible cause of liver cancer. More studies are being undertaken to clarify the problem.

Epidemiological surveys conducted in seriously affected localities in Ben Tre province (South Vietnam) have shown, by comparing results with those obtained in non-affected areas, the long-term noxious effects of defoliants on general human health. The following data have been noted :

Ailments	Exposed group	Non-exposed group
Gastro-duodenal disorders (including ulcers)	12.50 %	5.5 %
Chronic hepatitis	6.6 %	0.5 %
Neurosis, neurasthenia	12.5 %	3.5 %
Bucco-dental ailments	8.9 %	2 %

It is clear that the destruction of the environment leading to precarious living conditions and the stress weighing on the people living in areas subjected to repeated bombings, shellings and defoliant sprayings lie behind the bad health conditions prevailing in those regions. There remain to be elucidated the direct cause-effect links between the various chemicals and the symptoms and disorders observed.

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Chemical warfare conducted on a large scale and over long years in Vietnam has led to both immediate and persistent consequences that are extremely serious for both the natural environment and for man. Vietnam now confronts problems on a vast scale. In order to solve scientific and practical problems arising in the fields of economy and health, it needs considerable technical and financial means. Effective international assistance and cooperation are indispensable.

INTERNATIONAL SYMPOSIUM ON HERBICIDES AND DEFOLIANTS IN WAR: THE LONG-TERM EFFECTS ON MAN AND NATURE

Ho Chi Minh City, 14 — 19 January 1983

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3. SOUMPHOLPHALDY BOUNTHEUNG	Laos
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5. DANG SANG CANH	M. D., Vietnam
6. NGUYEN XUAN CU	(Biology), Vietnam
7. DO BINH DUONG	(Gyneco-obstetrics), Vietnam
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10. DINH HIEP	(Forestry), Vietnam
11. VI NGUYET HO (Mrs Ton That Tung)	(Anesthesia), Vietnam
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24. Professor TRINH VAN THINH	(Agriculture), Vietnam
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28. TRAN THI THAI	M. D., (Genetics), Vietnam
29. NGUYEN HOANG TRI	Candidate of Science, (Ecology), Vietnam
30. NGUYEN VAN TRINH	M. D., Vietnam
31. NGUYEN DINH VINH	(Forestry), Vietnam

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Plant Ecology	
● Thai Van Trung (Chair)	A. W. Galston (rapporteur)
● Hoang Hoe (Vice-Chair)	
Animal Ecology	
● Vo Quy (Chair)	E. W. Pfeiffer (rapporteur)
● Dang Huy Huynh (Vice-Chair)	
Soil Ecology	
● Hoang Van Huay (Chair)	P.J. Zinke (rapporteur)
● Le Trong Cuc (Vice-Chair)	
Coastal and Aquatic Ecology	
● Mai Dinh Yen (Chair)	S. C. Snedaker (rapporteur)
● Bui Thi Lang (Vice-Chair)	
Cancer and Clinical Epidemiology	
● Pham Bieu Tam (Chair)	S. S. Epstein (rapporteur)
● Luong Tan Truong (Vice-Chair)	
Reproductive Epidemiology	
● Nguyen Can (Chair)	J. D. Constable (rapporteur)
● Nguyen Thi Ngoc Phuong (Vice-Chair)	
Experimental Toxicology and Chemistry	
● Cung Binh Trung (Chair)	A. Hay (rapporteur)
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